Walla Walla River Fish Habitat Analysis Using the Instream Flow Incremental Methodology

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Washington State
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Walla Walla River
Fish Habitat Analysis Using the
Instream Flow Incremental Methodology

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SUMMARY

The Washington state departments of Ecology and Fish and Wildlife conducted an instream flow study in the Walla Walla River and Mill Creek using the Instream Flow Incremental Methodology (IFIM). The study provided information about the relationship between stream flow and fish habitat, which can be used in developing instream flow requirements for fish. Four key variables of fish habitat were examined:

- depth
- velocity (water movement)
- substrate (material on the stream bottom), and
- cover (material such as logs and boulders that provide shade and/or shelter from predators or fast moving water).

Four sites were chosen for study, each representing a specific stream reach. Field data were collected and entered into the IFIM hydraulic computer model to simulate the distribution of water depths and velocities with respect to substrate and cover under a variety of flows. The simulated habitat parameters were then used to generate the quantity (index) of available habitat at each modeled flow; this index is referred to as "weighted usable area" (WUA).

An IFIM study cannot, in and of itself, determine instream flow levels. The WUA graphs can only show whether an increase or decrease in stream flow will increase or decrease fish habitat based on depth, velocity, substrate, and cover.

Sometimes the maximum amount of available habitat occurs at a flow that is higher than what typically is found during the summer low flow period. This does not mean the model is incorrect. The model determines whether more or less flow makes more or less habitat based on the channel shape – not on the hydrology, which is constantly changing.

Whether an increase in habitat truly results in an increase in fish production will depend upon the many other factors that affect fish survival (such as water quality, dam passage survival, and predation). A discussion of some of the factors to consider when developing a flow regime is included later in this report.

This shortened version of the report does not include the 128 pages of appendices which provide technical details on the calibration of the hydraulic model. Please contact Ecology for a copy of the appendices.

ACKNOWLEDGEMENTS

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Introduction

The Department of Ecology (Ecology) is mandated by the Water Resources Act of 1971 (Chapter 90.54 RCW) to maintain base flows[1] "necessary to provide for preservation of wildlife, fish, scenic, aesthetic and other environmental values, and navigational values." The Department of Fish and Wildlife (WDFW) is mandated to "preserve, protect, perpetuate, and manage the wildlife and food fish, game fish …" (RCW 77.04.012); part of this mandate is to protect habitat, including stream flows. In determining appropriate base, or instream, flows for fish habitat, Ecology and WDFW often use the Instream Flow Incremental Methodology (IFIM) to generate some of the necessary information.

Four sites were chosen for the current study, each composed of eight or nine transects. Three sites were in the Walla Walla River:

1) just downstream of Mill Creek at River Mile (RM) 32.9
2) downstream of Yellowhawk Creek at RM 36.5
3) immediately downstream of the State Route 125 over-pass at RM 38.7.

A fourth site was in Mill Creek, immediately upstream of the Wallula Road bridge at RM 2.7. Depths and velocities were measured at three to four different flow levels, and substrate was recorded at low flows.

Project Background

Location and Description

The Walla Walla River is located in southeastern Washington and northeastern Oregon. In Washington the river flows through Walla Walla County. The Walla Walla River headwaters and tributaries originate in the Blue Mountains at an elevation of about 6,000 feet and enter the Columbia River at Lake Walula behind McNary Dam at an elevation of about 260 feet. Steep, timbered terrain in the upper elevations and moderate slopes and level terrain at lower elevations characterize the Walla Walla drainage, which covers an area of about 1,760 square miles. The Walla Walla River flows through narrow well-defined canyons in the upper elevations and through broad low gradient valleys in the lower portion of the basin. Major tributaries to the Walla Walla River include the Touchet River, Mill Creek and the North and South Forks of the Walla Walla River.

The climate within the Walla Walla basin varies widely depending on the time of year. Temperatures range from over 100 degrees F in the summer months to below 0 degrees F in the winter, although winter temperatures close to freezing are more typical. Precipitation varies depending on elevation. The upper reaches of the watershed receive about 40 inches of precipitation annually, primarily as snow. Annual precipitation at the mouth of the river is approximately 10 inches per year, usually in the form of rain.

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[1] In statute, the term "base flow" is used synonymously with the terms "instream flow" and "minimum instream flow." "Stream flow" refers to the amount of water flowing in a stream.

Water Quality

Monitoring of water quality on the Walla Walla River has indicated excursions (a situation where water quality conditions do not meet the standards) of temperature, pH, fecal coliform, nitrates, and pesticides. Monitoring of the river is conducted by Ecology on a monthly basis at ambient monitoring station 32A070 located at River Mile 15.3, near the town of Touchet. The Walla Walla River is listed on the Ecology's 303(d) list of water bodies which fail to meet state water quality standards.

Hydrology

As precipitation begins to diminish in the spring, stream flow in the Walla Walla River is supplemented by melting snow from the Blue Mountains. As precipitation further diminishes throughout the summer, the higher elevation snow melts away. Some intermittent tributaries dry up in the summer, substantially reducing flow to the Walla Walla River. Other tributaries have minimal flows during the summer months. Human water use is also a cause of low flows. Complete dewatering of some segments of the river and certain tributaries are due largely to water diversions during the summer irrigation season. This dewatering has been documented on the Walla Walla River near the Oregon-Washington border, in the lower Touchet River, and in the lower reaches of Mill Creek (James et al. 2001).

Specific hydrological data is available from the United States Geological Survey (USGS), which provides daily exceedance flow values for the streams and rivers throughout Washington. (Exceedance flows are the flows expected to be exceeded a specific percentage of the time: e.g. the 50 percent exceedance flow would be exceeded 50 percent of the time.) Data from some of the USGS gauge sites within the Walla Walla River basin are graphed in Figures 11-20.

In Figure 11, for example, the flow data for the Walla Walla River near Touchet gauge is portrayed with 10, 50, and 90 percent exceedance flows. The 50 percent exceedance flow is the median flow. Its values are close to but usually lower than the average flow. The 90 percent exceedance flow is exceeded 90 percent of the time. This can be thought of as a 1-in-10-year low flow for a given date. The 10 percent exceedance flow is roughly the 1-in-10-year high flow for a given date. One can expect about 80 percent of the flow values to fall within the 10 to 90 percent exceedance range.

Exceedance flows are a useful tool for looking at the "normal" flow of a river. Although it might seem logical to represent the "normal" flow as a number such as the average monthly flow, such a number is often one that has never been recorded as a daily flow. Averages are frequently skewed toward high numbers because of short-term rain events. It is therefore more appropriate to describe the "normal" flow in the river using the 10 to 90 percent range.

These graphs show the range of flows expected throughout the year based on recorded data. Figure 11 is based upon daily averages from the 1951-2000 period of record obtained from the USGS gauge near Touchet at river mile 18.2, which is downstream from the study sites in this report. The natural or historic flow is unknown since the existing gauge did not start until 1951, over a century after surface and ground water diversions began. The hydrographs in Figures 11 – 20 only show the normal range of river flows with past and existing diversions in use.

While conducting field measurements for the 2000 Walla Walla IFIM study, spot measurements were taken on some of the Walla Walla River tributaries. The results are as follows:

East Little Walla Walla River at Springfield Road	14 cfs	5/24/2000
West Little Walla Walla River at Sweagle Road	1.7 cfs	5/25/2000
Yellowhawk Creek near its mouth	43 cfs	5/24/2000
Stone Creek at Sweagle Road	0.1 cfs (est.)	5/25/2000
Cold Creek at its mouth	0.1 cfs (est.)	5/25/2000
Mill Creek at Sweagle Road	37 cfs	5/25/2000
Mud Creek near its mouth	3 cfs	5/25/2000
Pine Creek near its mouth	7.5 cfs	5/25/2000

Fishery Status

(Note: We relied heavily on the work of James et al. and their 2001 report on the Walla Walla Subbasin for the factual details included in this section.)

Many types of anadromous fish once lived in the Walla Walla basin, including spring and fall chinook as well as coho and chum salmon. Currently the only naturally occurring anadromous fish are summer steelhead. Adult spring chinook have recently been stocked into the basin.

In the reach of the Walla Walla studied (from the Oregon state line downstream to just below where it joins Mill Creek), juvenile steelhead are the primary life stage and species, with some use by juvenile chinook and spawning steelhead. Bull trout have also been found, but in small numbers. Chinook are not likely to spawn to any great extent in this area due to warm water during their spawning season, the fall. Fall chinook use the study area primarily as hatchery stray adults. Summer steelhead and spring chinook are discussed in more detail subsequently.

In the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI), summer steelhead stock are identified as being "depressed." A depressed stock is defined as one whose production is below expected levels, based on available habitat and natural variation in survival rates, but above where permanent damage is likely.

Steelhead, spring chinook, and bull trout in the Walla Walla basin are listed as threatened under the Endangered Species Act (ESA). Provisions of the ESA prohibit "taking" (i.e. the killing, harassing, or harming) of listed species. Diverting water to the point where fish or their habitats are significantly impacted is considered to be a "taking" of listed species.

Summer Steelhead

Summer steelhead (*Oncorhynchus mykiss*) are found throughout the Walla Walla watershed. Steelhead return after two years of ocean residence, unlike other Columbia basin runs which typically return after one year in saltwater. The spawning migration can begin as early as September with spawning from February to early June.

After steelhead spawn, their eggs remain in nests (redds) in the gravel for a period of several weeks up to several months, depending on temperature. The eggs hatch and young fry about one inch long emerge from the gravel in summer. They rear (feeding and growing) through the remainder of the summer, through the following winter, and for another year in the stream before going to sea in the spring. By this time they are about two years old and about 5 to 12 inches in length. Some rear longer before going to the sea ("outmigration"). Most spend at least one year at sea and return at lengths of about 24 inches or more.

The status of the summer steelhead stock is listed as "depressed" in the SASSI report due mainly to long term degradation of habitat and water withdrawal. Other factors include water quality problems, particularly high water temperatures. Out of basin influences such as migration losses at hydropower facilities along the Columbia River and poor ocean conditions also affect this summer steelhead stock. The number of returning steelhead has declined over the last decade according to the state of Oregon's escapement estimates (James et al. 2001).

Spring Chinook
Spring chinook (*Oncorhynchus tshawytscha*) stock were once abundant in the Walla Walla basin. The last large run was in 1925 and the species was gone by the 1950's. Habitat and passage problems from low flows due primarily to agricultural water diversions and land use practices are believed to have been the major cause of the loss of this species (James et al. 2001).

Ongoing local efforts have repaired and improved habitat and passage throughout the basin. Areas with suitable habitat include the North and South Forks of the Walla Walla River, upper Mill Creek, and upper Touchet River. James et al. reported that some adult spring chinook were transplanted to southern portions of the South Fork Walla Walla River and Mill Creek for spawning.

Spring chinook spawn in the upper reaches of a river system where water remains cool throughout the summer. Adults spawn in late August and September after returning from the ocean in spring or early summer and holding through summer in suitable habitat near the spawning area. The eggs hatch and young fry about 1.5 inches long emerge from the gravel in late winter. They rear (feeding and growing) through the spring, summer, and through the following winter, and then go to sea in the spring when they are about one year old and about 3 to 5 inches in length. Some rear longer before outmigration. Most spend at least one year at sea and return at lengths of about 24 inches or more.

Low Flows as a Limiting Factor
James et al., in their 2001 report on the Walla Walla mainstem, found that insufficient stream flows were a primary factor contributing to the depressed status of key fish species (steelhead, spring chinook, bull trout and lamprey). In lower portions of the Walla Walla, Mill Creek, Dry Creek, and Touchet River, access to higher quality habitat upstream may be limited by low stream flows.

In response to the low flow problem, the Bi-State Policy Group (led by Washington state representative Dave Mastin) developed short-term solutions for five reaches identified as in immediate need of increased flows. These reaches were:

- Walla Walla River at Tumalum
- Mill Creek at Wilbur Avenue
- Cottonwood Creek at Powerline Road
- Dry Creek at Dixie
- South Fork of the Touchet River mouth.

The Bi-State Policy Group's work, along with other actions, required the districts to leave a minimum flow of 13 cfs in the mainstem Walla Walla River past Nursery Bridge (including Tumalum), and 10 cfs past Burlingame Dam for the summer of 2000. The increased flows in these reaches created some habitat improvement, but not enough to significantly increase salmonid survival. For example, the stream flow was ultimately lost subsurface and to evaporation in the area of Tumalum Bridge, which left a significant reach without water during the summer months.

While low stream flows are clearly identified as limiting aquatic productivity, James et al. note several other contributing factors. These include high water temperatures, passage impediments and high sedimentation.

Study Methods

Overview of IFIM

The Instream Flow Incremental Methodology (IFIM) was selected as the best available method for predicting how the quantity of available fish habitat changes in response to incremental changes in stream flow. This methodology was developed by the U.S. Fish and Wildlife Service in the late 1970s (Bovee 1982). The IFIM involves putting site-specific stream flow and habitat data into a group of models collectively called PHABSIM (**P**hysical **HAB**itat **SIM**ulation). PHABSIM was and is the most commonly used hydraulic modeling program within IFIM to predict depths and velocities in streams.

In the 1990's, Thomas R. Payne and Associates (Arcata, CA) rewrote the PHABSIM program creating a version called RHABSIM (**R**iverine **HAB**itat **SIM**ulation). RHABSIM was chosen for the present study because it is a more user-friendly program, compatible with the Windows operating system. PHABSIM and RHABSIM produce similar depth and velocity predictions.

The IFIM is used nationwide and is accepted by most resource managers as the best available tool for determining the relationship between flows and fish habitat (Reiser, et al. 1989). However, the methodology only uses four variables in hydraulic simulation. At certain flows, such as extreme low flows, other variables such as fish passage, food supply (aquatic insects), competition between fish species, and predators (birds, larger fish, etc.) may be of overriding importance. In addition to the PHABSIM or RHABSIM models, IFIM may include water quality, sediment, channel stability, temperature, hydrology, and other variables that affect fish production. These additional variables are not analyzed in this report.

RHABSIM Process: in brief

The process of quantifying how the amount of available fish habitat changes in response to incremental changes in stream flow is as follows:

1. Collect data in the field: velocity, depth, substrate and cover measurements.
2. Enter data into hydraulic model and calibrate.
3. Enter data in habitat preference model.
4. Calculate Weighted Usable Area (WUA): Combine the predicted depths and velocities (from the hydraulic model) with the depths and velocities preferred by fish (from the habitat preference model). This provides what flows the fish prefer based on the depths and velocities they prefer: the WUA.

RHABSIM Process: in detail

The on-site data is collected and entered into HYDSIM (**HYD**raulic **SIM**ulation), a hydraulic computer model which deals with the movement and force of water. Several hydraulic modeling options are available in HYDSIM. Velocity can be calculated by regression and interpolation and extrapolation based on measured velocities at several flows. Alternatively, velocity at a single flow can be used to solve Manning's equation. These are discussed later in this report, in the section titled "Hydraulic Model."

HYDSIM uses multiple transects to predict depths and velocities in a river over a range of flows. It creates a cell for each measured point along the transect or cross-section. Each cell has an average water depth and water velocity associated with a type of substrate or cover for a particular flow. The cell's area is measured in square feet. Fish habitat is defined in the computer model by the variables of velocity, depth, substrate, and/or cover. These are important habitat variables that can be measured, quantified, and predicted.

After the HYDSIM model is calibrated (that is, adjusted to the situation being modeled) and run, its output is entered into another model (HABSIM, **HAB**itat **SIM**ulation) with data describing fish habitat preferences. These preferences vary by fish species and life stage (spawning and juvenile rearing).

The output of the HABSIM model is an index of fish habitat known as Weighted Useable Area (WUA). The preference factor for each variable in a cell is multiplied by the other variables to arrive at a composite, preference factor for that cell. For example, a velocity preference of 1.0 multiplied by a depth preference of 0.9, then multiplied by a substrate preference of 0.8 equals a composite factor of 0.72 for that cell:

velocity 1.0 x depth 0.9 x substrate 0.8 = 0.72, preference factor for that cell

This composite-preference factor is multiplied by the number of square feet of area in that cell.

A summation of all the transect cells' areas results in the total number of square feet of preferred habitat available at a specified flow. The final model result is a listing of units of square feet of habitat per 1,000 feet of stream. The WUA values are listed with their corresponding flows (given in cubic feet per second). See Figures 3 - 6.

Study Site and Transect Selection

Preliminary study sites were selected for the IFIM study with assistance from Glen Mendel and staff from WDFW, who provided local knowledge of fish distribution and habitat characteristics. Mendel and his staff were a valuable resource in site selections for this study. Hal Beecher (WDFW) and Mendel identified reaches of interest by flying over the basin from the Oregon border to the Walla Walla River confluence with the Columbia River in October 1998. These reaches were delineated on topographic maps.

Studies were directed at reaches between the confluence of the Touchet River and the Oregon state line. Within this part of the river are areas typical of the habitats used by salmonids, and areas affected by water management and future management options. Final site selections were made after on-site visits and access was secured with private property owners.

Four sites were chosen for the current study, each composed of eight or nine transects. Depths and velocities were measured at three to four different flow levels, and substrate was recorded at low flows.

Three sites were in the Walla Walla River:

1) just downstream of Mill Creek at River Mile (RM) 32.9
2) downstream of Yellowhawk Creek at RM 36.5
3) immediately downstream of the State Route 125 over-pass at RM 38.7.

A fourth site was in Mill Creek, immediately upstream of the Wallula Road bridge at RM 2.7. (Lower mainstem Walla Walla reaches were not addressed further because present salmonid use is limited to migration.)

The river mile location and the distances between transects are listed on the following page.

Maps indicating the four study sites are displayed in Figures 1 and 2.

Walla Walla River and Mill Creek Study Site Locations

Transect #	Location: Walla Wall River just downstream of SR 125.
1	River Mile **38.7**
2	78 feet upstream of #1
3	98 feet upstream of #2
4	102 feet upstream of #3
5	145 feet upstream of #4
6	89 feet upstream of #5
7	53 feet upstream of #6
8	102 feet upstream of #7

Transect #	Location: Walla Walla River just downstream of Yellowhawk Creek confluence.
1	River Mile **36.5**
2	51 feet upstream of #1
3	60.5 feet upstream of #2
4	97 feet upstream of #3
5	76 feet upstream of #4
6	147.5 feet upstream of #5
7	77 feet upstream of #6
8	75.5 feet upstream of #7

Transect #	Location: Walla Walla River just downstream of Mill Creek confluence.
1	River Mile **32.9**
2	122 feet upstream of #1
3	122 feet upstream of #2
4	100 feet upstream of #3
5	104 feet upstream of #4
6	117 feet upstream of #5
7	102 feet upstream of #6
8	59 feet upstream of #7
9	60 feet upstream of #8

Transect #	Location: Mill Creek just upstream of Wallula Road Bridge.
1	River Mile **2.7**
2	29 feet upstream of #1
3	28 feet upstream of #2
4	25 feet upstream of #3
5	22 feet upstream of #4
6	107 feet upstream of #5
7	105 feet upstream of #6
8	173.5 feet upstream of #7

Figure 1. Upper Walla Walla River IFIM Sites.

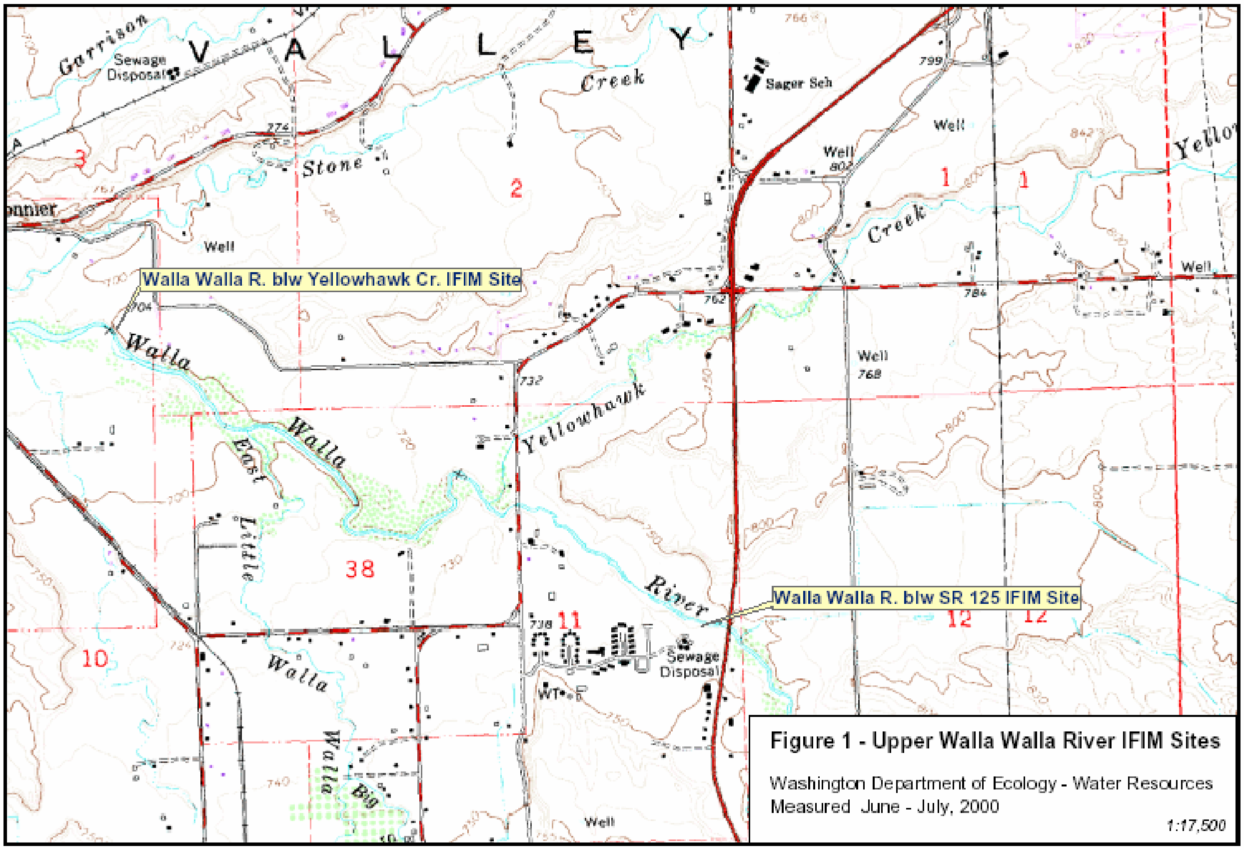
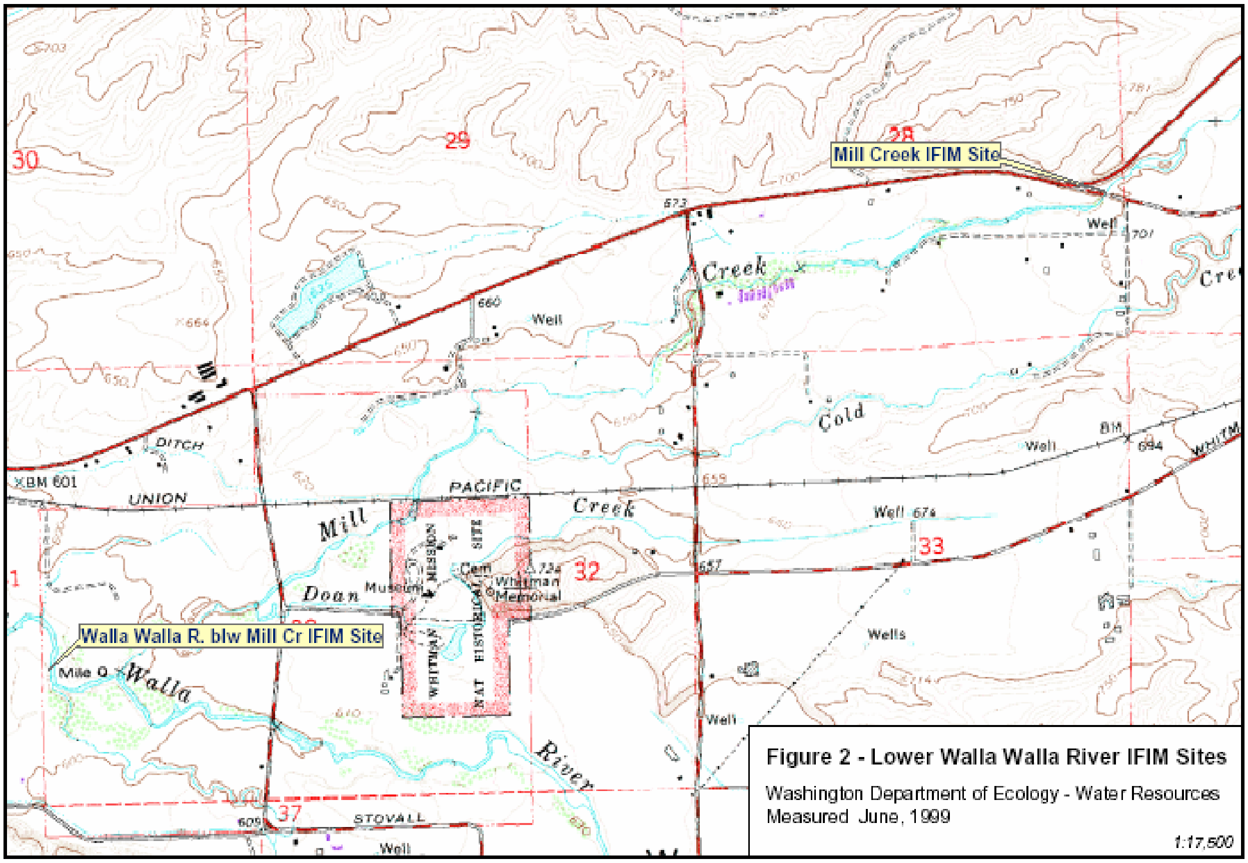


Figure 2. Lower Walla Walla River IFIM Sites.



Field Procedures/Data Collection
IFIM measurements were taken in June and July of 1999 at the following sites and flows:

- Walla Walla River below Mill Creek study site at 180, 70 and 21 cfs
- Mill Creek just upstream of the Wallula Road crossing study site at 56, 25 and 5 cfs.

In June and July of 2000, measurements were taken at :

- Walla Walla River below Yellowhawk Creek at 327, 130, 68 and 46 cfs
- Walla Walla below SR 125 study sites 202, 64, 13 and 6 cfs.

A temporary gauge at each site was used to verify that stream flow rates at each transect remained steady during measurement. Transects were marked using survey hubs and flagging. Water velocity was measured using standard USGS methods with a calibrated Swoffer velocity meter mounted on a top-set wading rod. Depth and velocity were recorded at fixed locations along measuring tapes stretched across transects at each measured flow.

Water surface elevations and stream-bank profiles were surveyed with a survey level and stadia rod. These points were referenced to an arbitrary, fixed benchmark. Substrate composition and cover were assessed by visually estimating the percentage of the two main particle size classes and type of cover present (Appendix D).

Hydraulic Model

This section in brief: The field data is entered into the hydraulic model and calibrated, ensuring that the depths and velocities predicted by the model match the measured depths and velocities as closely as possible.

This section in detail:
Calibration Philosophy
Calibration of the hydraulic model involved checking the velocities and depths predicted by the model against velocities and depths measured in the field. This included examining indicators of the model's accuracy such as the Velocity Adjustment Factor (VAF). Input data were changed or manipulated only when doing so would improve the model's ability to extrapolate without reducing the accuracy of predicted depths and velocities at the measured calibration flows.

Calibration of the RHABSIM Version 2 model was done cell by cell for each transect to decide whether the predicted cell velocities adequately represented measured velocities. Generally, if the predicted cell velocity at the calibration flow was within 0.2 feet per second (fps) or 20% of the measured cell velocity, the predicted velocity was considered adequate. Any change to a calibration velocity was usually limited to a change of 0.2 fps or 20% of the measured cell velocity. The 0.2 fps or 20% of the measured cell velocity was thought to be reasonable considering the normal range of velocity measurement error. All cell velocities were reviewed at the highest and lowest extrapolated flows to ensure that extreme cell velocities were not predicted.

Indicators of Model Accuracy
One indicator of the HYDSIM model's accuracy in predicting depths and velocities is the Velocity Adjustment Factor (VAF). See Appendix B for VAFs and other calibration details and data changes for each transect at each site.

The VAF for a three-velocity regression hydraulic model indicates whether the flow predicted from the velocity/discharge regressions matches the flow predicted from the stage/discharge regressions. The velocities predicted from the velocity/discharge regressions for a transect are all multiplied by the same VAF to achieve the flow predicted from the stage/discharge regression. Calculating and comparing the flows predicted from two different regressions gives an indication as to whether or not some of the model's assumptions are being met.

In VAF value ranges (Milhous, et al. 1989):
- 0.9 to 1.1 is considered good,
- 0.85 to 0.9 and 1.1 to 1.15 is fair,
- 0.8 to 0.85 and 1.15 to 1.20 is marginal
- less than 0.8 and more than 1.2 is poor.

The standard extrapolation range is 0.4 times the low measured flow to 2.5 times the high measured flow. The extrapolation range of the model is usually limited when two or more transects have VAFs which fall below 0.8 or above 1.2.

In the case of the single velocity models, velocity simulations are based on Manning's N values calculated for individual cells across each transect. These Manning's N values are derived from a single set of depth and velocity measurements at each transect. The Manning's N values are used at each wetted cell throughout all simulated flows. A VAF based on the ratio between the calculated flow (using Manning's N) and the simulated flow is applied to all predicted velocities.

Since the model uses the same Manning's N value in a particular cell at all simulated flows, Manning's N values were adjusted as needed in order to more reasonably predict simulation velocities. Changes to actual calibration velocities were usually limited to cells at the channel edge where velocity simulation can be problematic.

Site Specific Calibration
For the Mill Creek just upstream of Wallula Road crossing study site a three-velocity regression hydraulic model with eight transects was created with RHABSIM with an extrapolation range of 3 to 135 cfs. The water surface elevations were modeled using a log-log regression of the three measured flows.

For the Walla Walla River below Yellowhawk Creek study site a three-velocity regression hydraulic model with eight transects was created with RHABSIM with an extrapolation range of 15 to 500 cfs. The water surface elevations were modeled using a log-log regression of four measured flows.

For the Walla Walla below SR 125 study site two different one-velocity hydraulic models with eight transects each were created with RHABSIM with an extrapolation range of 3 to 325 cfs.

The first model simulated flows from 3 to 13 cfs using the velocities from the 13 cfs measured flow. The second model simulated flows from 15 to 325 cfs using the velocities from the 64 cfs measured flow. Due to the nature of the hydraulic dynamics of this site it was decided that two one-flow models would be more accurate than a three-velocity regression. The water surface elevations were modeled using a log-log regression of four measured flows.

See Appendix A for the input files showing the distance along the transects with the corresponding bed elevations, velocities, substrate/cover, and water surface elevations. See Appendix B for calibration details, velocity adjustment factors, and changes to data.

For the Walla Walla River below Mill Creek study site a three-velocity regression hydraulic model with nine transects was created with RHABSIM with an extrapolation range of 10 to 350 cfs. The water surface elevations were modeled using a log-log regression of the three measured flows.

Transect Weighting

Transect weighting is the percentage of weight given to one transect's WUA results as compared to all the other transects. It shows which transects have the most effect on the final WUA results.

The table below lists the percent weighting each transect received relative to the whole site. Transect weighting is determined in one of two ways: either the model automatically determines weighting for each transect by using the distance between the transects, or transect weight is set to predetermined levels by specifying distances between transects and upstream weighting (referred to as composite weighting). Composite weighting is done when the transects are located far apart and the distances between the transects would create incorrect weighting, or the investigator wants to increase the weight of a particular type of fish habitat for that site. Transect weighting for the Walla Walla River site was done using the distances between the transects.

Transect Weighting for the Walla Walla River and Mill Creek Study Sites

Transect #	1	2	3	4	5	6	7	8	9
Percent of Study Site									
Walla Walla River below Mill Creek	8%	16%	14%	13%	14%	14%	10%	8%	4%
Walla Walla River below Yellowhawk Creek	4%	10%	13%	15%	19%	19%	13%	6%	N/A
Walla Walla River below SR 125	6%	13%	15%	19%	18%	11%	12%	8%	N/A
Mill Creek at Wallula Rd.	3%	6%	5%	5%	13%	22%	28%	18%	N/A

Habitat Use Model (HABSIM)
The HABSIM program combines the depths and velocities predicted from the HYDSIM hydraulic model with the depths, velocities, cover, and substrate preferences from the habitat-use curves. The HABSIM program calculates WUA for each flow modeled.

Habitat Preference Curves
Habitat preference curves for steelhead and chinook juveniles were developed as composites from several sites around Washington, including upper Mill Creek and two Blue Mountain streams, Asotin Creek and Tucannon River.

Biologists snorkeled stream reaches and marked locations of fish with weighted flags. Depth, velocity, and substrate were measured and recorded at fish locations. Depth, velocity, and substrate used by fish were compared to available habitat as determined from regularly spaced measurements on a grid over the stream reach (Beecher, Caldwell, and DeMond, 2002).

Fish preference curves for the Walla Walla River were agreed to by Ecology (Brad Caldwell) and WDFW (Hal Beecher) on March 13, 2001. Existing agency preference curves were used for chinook and steelhead juvenile substrate and cover as well as steelhead spawning. These preference curves are listed in Appendix C.

Factors to Consider When Developing a Flow Regime

No instream flow recommendations are made in this report. The process of determining instream flows for the Walla Walla basin will require a complex negotiation process, taking into account numerous factors. Instream flows need to be discussed in the context of the long-range water and fishery management objectives desired by the local watershed planning groups, state and federal natural resource agencies and affected Tribes.

Different fish species and life stages exist simultaneously in the river and each has a different flow requirement. Instream flows must include flows necessary for incubation of fish eggs, smolt out-migration, fish passage to spawning grounds, and prevention of stranding of fry and juveniles, for each species. Each fish species and life stage will need to be ranked, and competing life stages balanced against each other. Clearly, no single flow number will simultaneously provide optimum habitat for all fish species and life stages.

Integration of the WUA graphs alone will not show what the instream flow should be. The graphs show whether an increase or decrease in stream flow will increase or decrease fish habitat based on depth, velocity, substrate, and cover. Since only these four variables are considered, it is important to remember that other factors also impact the amount of useable fish habitat. The WUA graph may show that an increase in stream flow will result in increased fish habitat, but fish habitat may not actually be increased if other factors such as water quality are at limiting levels.

It is important to note that sometimes WUA reaches its maximum at a flow that is greater than what typically occurs. This is an indication that low flow may limit the population at that time of year. It does not mean that the model is incorrect. The model shows how much water provides how much habitat in a given stream channel, regardless of hydrology. The model addresses hydraulics, which is a function of channel shape, but not hydrology.

In addition to WUA, an instream flow recommendation requires the evaluation and incorporation of environmental variables other than habitat that affect fish survival, such as dam passage survival, water temperature, harvest and ocean survival. Water quality, the natural hydrology and sediment load should also be considered. Reaching a conclusion about an appropriate instream flow involves integrating the results of the IFIM study with consideration of these environmental variables.

Under the state's Water Resources Act of 1971 (Ch. 90.54 RCW), which guides Ecology in setting instream flows, an instream flow level must protect and preserve fish and all other environmental values. However, it is important to understand that instream flows set in rule cannot take away existing water rights; instream flows have a priority date like any water right, and therefore only affect water rights that are junior to it. In this way, instream flows are limited in what they can accomplish in protecting instream values, since no existing legal water users can be required by the state to put water in the stream to get the flow up to the calculated instream flow, even if the existing legal diverters are drying up the stream.   In fact, instream flow rules serve to protect existing water right users by restricting new upstream diverters.

It is important for the reader to remember that instream flows may differ depending on whether they were determined under state or federal laws. State laws have different goals and objectives than federal laws, and therefore instream flows or target flows may not be the same.

Results

The study results are summarized in three types of graphs (Figures 3 - 10 and Tables 1 - 4):

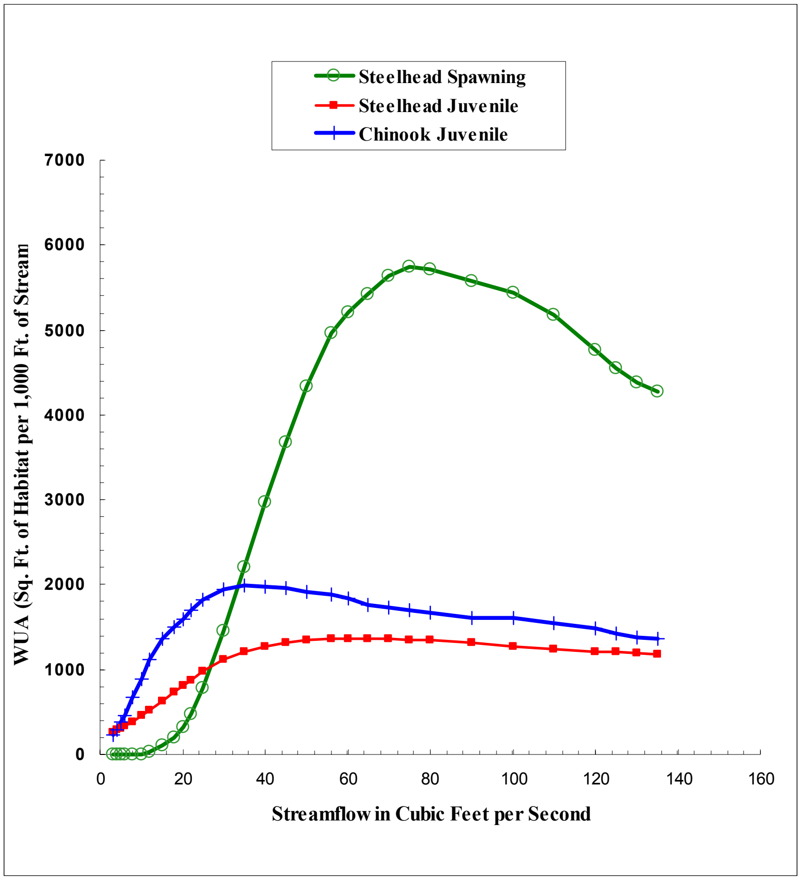
- ***fish habitat (WUA) versus flow graphs*** show the increase or decrease in the amount of fish habitat that results with an increase or decrease in stream flow
- ***percent of peak habitat versus flow tables*** show the percentage of increase or decrease in habitat with a loss or gain of stream flow from the highest possible amount of WUA
- ***wetted stream width versus flow graphs*** show the amount of stream width that is increased or decreased with an increase or decrease in flow.

These tables show whether there is a gain or loss in fish habitat or width for a given increase or decrease in flow.

Hydrographs

Flow Exceedance Probability Hydrographs (Figures 11 – 20), based on data collected from USGS gauges, follow the study results. These hydrographs are presented so that the reader can compare the WUA results to the likelihood that certain stream flows will actually be available. For example, if a specific spawning flow is desired for steelhead in May, will there be enough water for incubating the eggs until they hatch and the fry emerge in July. These are the kinds of questions the hydrographs can help answer. (For additional details, see the section on Hydrology at the beginning of this document, under "Project Background.")

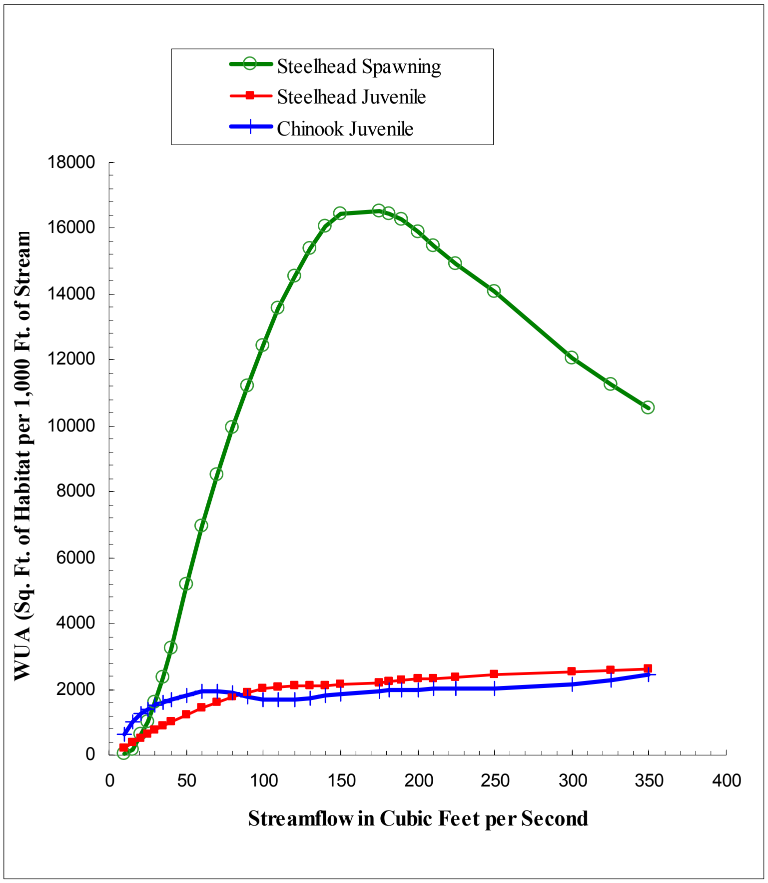
Figure 3. Mill Creek above Wallula Road: Fish Habitat (WUA) vs Flow.



Flow (cfs)	Steelhead Spawning	Steelhead Juvenile	Chinook Juvenile
3	0	261	233
4	0	285	296
5	0	308	376
6	0	333	460
8	0	390	673
10	5	454	889
12	37	519	1124
15	101	621	1359
18	204	733	1507
20	318	807	1591
22	470	879	1693
25	785	978	1816
30	1459	1113	1939
35	2210	1208	1995
40	2967	1275	1980
45	3679	1318	1960
50	4341	1346	1909
56	4959	1367	1885
60	5208	1367	1841
65	5424	1362	1766
70	5635	1359	1726
75	5742	1355	1695
80	5710	1350	1664
90	5577	1312	1615
100	5442	1271	1609
110	5178	1237	1541
120	4769	1214	1480
125	4554	1203	1427
130	4384	1190	1378
135	4275	1177	1356

Table 1. Percent of Peak Habitat vs Flow for Mill Creek.			
Flow (cfs)	**Steelhead Spawning**	**Steelhead Juvenile**	**Chinook Juvenile**
3	0%	19%	12%
4	0%	21%	15%
5	0%	23%	19%
6	0%	24%	23%
8	0%	29%	34%
10	0%	33%	45%
12	1%	38%	56%
15	2%	45%	68%
18	4%	54%	76%
20	6%	59%	80%
22	8%	64%	85%
25	14%	72%	91%
30	25%	81%	97%
35	38%	88%	**100%**
40	52%	93%	99%
45	64%	96%	98%
50	76%	98%	96%
56	86%	**100%**	94%
60	91%	**100%**	92%
65	94%	**100%**	89%
70	98%	99%	87%
75	**100%**	99%	85%
80	99%	99%	83%
90	97%	96%	81%
100	95%	93%	81%
110	90%	90%	77%
120	83%	89%	74%
125	79%	88%	72%
130	76%	87%	69%
135	74%	86%	68%

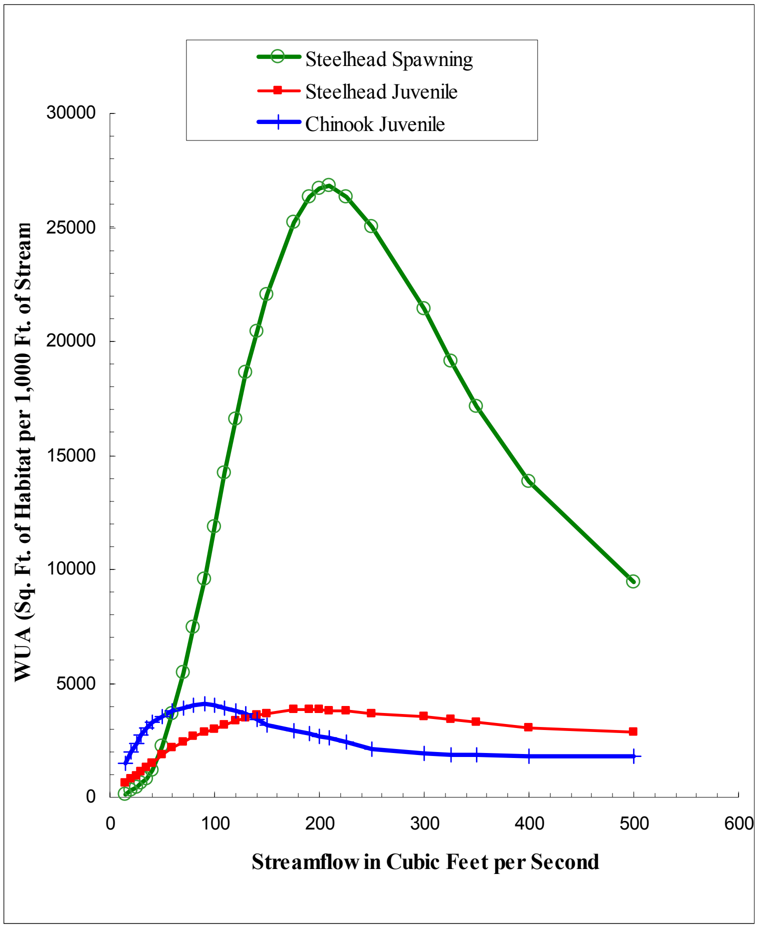
Figure 4. Walla Walla below Mill Creek: Fish Habitat (WUA) vs Flow.



Flow (cfs)	Steelhead Spawning	Steelhead Juvenile	Chinook Juvenile
10	31	231	616
15	182	359	1015
21	625	519	1263
25	1027	629	1392
30	1601	754	1525
35	2366	875	1619
40	3236	994	1685
50	5168	1220	1796
60	6971	1419	1931
70	8519	1617	1954
80	9928	1783	1900
90	11226	1909	1758
100	12446	2019	1688
110	13556	2076	1670
120	14536	2105	1698
130	15372	2112	1732
140	16065	2124	1798
150	16444	2143	1867
175	16513	2204	1947
182	16429	2233	1966
190	16272	2267	1971
200	15889	2308	1980
210	15463	2339	2012
225	14915	2373	2017
250	14085	2430	2034
300	12069	2535	2139
325	11243	2560	2287
350	10540	2613	2432

Table 2. Percent of Peak Habitat vs Flow for Walla Walla River below Mill Creek.			
Flow (cfs)	**Steelhead Spawning**	**Steelhead Juvenile**	**Chinook Juvenile**
10	0%	9%	25%
15	1%	14%	42%
21	4%	20%	52%
25	6%	24%	57%
30	10%	29%	63%
35	14%	33%	67%
40	20%	38%	69%
50	31%	47%	74%
60	42%	54%	79%
70	52%	62%	80%
80	60%	68%	78%
90	68%	73%	72%
100	75%	77%	69%
110	82%	79%	69%
120	88%	81%	70%
130	93%	81%	71%
140	97%	81%	74%
150	**100%**	82%	77%
175	**100%**	84%	80%
182	99%	85%	81%
190	99%	87%	81%
200	96%	88%	81%
210	94%	90%	83%
225	90%	91%	83%
250	85%	93%	84%
300	73%	97%	88%
325	68%	98%	94%
350	64%	**100%**	**100%**

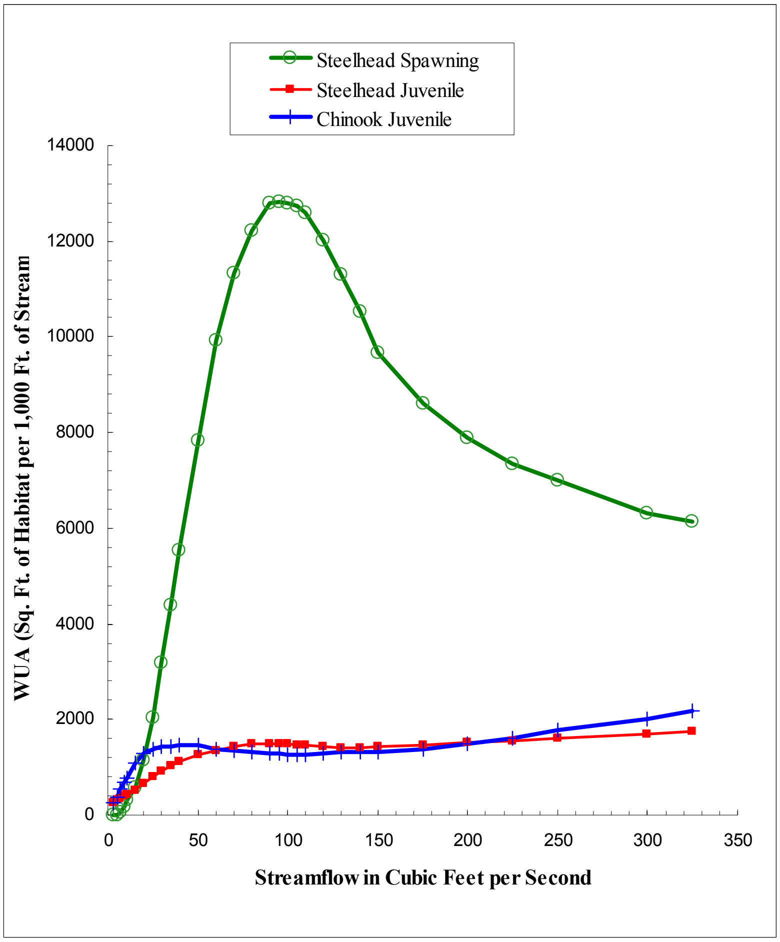
Figure 5. Walla Walla River below Yellowhawk Creek: Fish Habitat (WUA) vs Flow.



Flow (cfs)	Steelhead Spawning	Steelhead Juvenile	Chinook Juvenile
15	155	644	1463
20	285	797	1987
25	438	955	2357
30	608	1125	2763
35	812	1309	3051
40	1153	1491	3271
50	2249	1850	3564
60	3679	2163	3760
70	5454	2436	3913
80	7426	2662	4068
90	9578	2830	4105
100	11866	3002	4029
110	14240	3166	3903
120	16555	3327	3810
130	18650	3472	3641
140	20434	3592	3393
150	22054	3692	3193
175	25237	3850	2940
190	26359	3849	2797
200	26733	3827	2681
210	26839	3808	2592
225	26332	3769	2412
250	25012	3670	2117
300	21416	3524	1901
325	19128	3400	1877
350	17133	3282	1869
400	13835	3069	1828
500	9416	2865	1799

Table 3. Percent of Peak Habitat vs Flow for Walla Walla River below Yellowhawk Creek.			
Flow (cfs)	**Steelhead Spawning**	**Steelhead Juvenile**	**Chinook Juvenile**
15	1%	17%	36%
20	1%	21%	48%
25	2%	25%	57%
30	2%	29%	67%
35	3%	34%	74%
40	4%	39%	80%
50	8%	48%	87%
60	14%	56%	92%
70	20%	63%	95%
80	28%	69%	99%
90	36%	74%	**100%**
100	44%	78%	98%
110	53%	82%	95%
120	62%	86%	93%
130	69%	90%	89%
140	76%	93%	83%
150	82%	96%	78%
175	94%	**100%**	72%
190	98%	**100%**	68%
200	**100%**	99%	65%
210	**100%**	99%	63%
225	98%	98%	59%
250	93%	95%	52%
300	80%	92%	46%
325	71%	88%	46%
350	64%	85%	46%
400	52%	80%	45%
500	35%	74%	44%

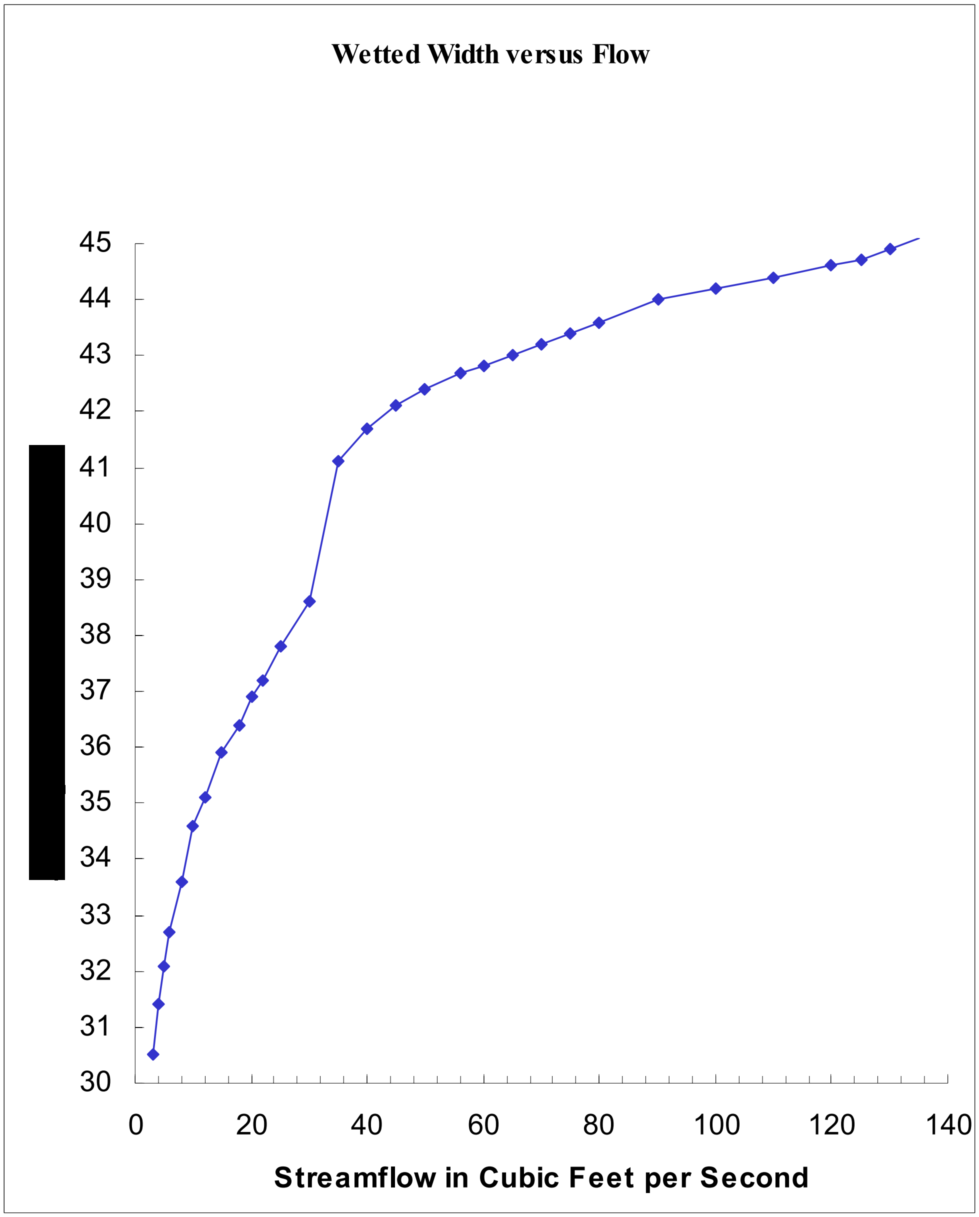
Figure 6. Walla Walla River below HWY 125: Fish Habitat (WUA) vs Flow.



Flow (cfs)	Steelhead Spawning	Steelhead Juvenile	Chinook Juvenile
3	0	261	250
5	11	303	363
7	55	348	541
9	166	391	688
11	328	433	774
15	565	520	1099
20	1144	660	1285
25	2043	796	1382
30	3197	926	1423
35	4394	1031	1445
40	5547	1121	1461
50	7844	1249	1451
60	9940	1348	1375
70	11328	1443	1349
80	12215	1482	1312
90	12796	1493	1292
95	12831	1487	1284
100	12800	1479	1273
105	12739	1472	1263
110	12599	1460	1267
120	12007	1430	1299
130	11309	1414	1323
140	10521	1419	1320
150	9679	1427	1318
175	8611	1476	1390
200	7895	1527	1481
225	7347	1553	1617
250	6990	1609	1765
300	6322	1703	2016
325	6133	1756	2193

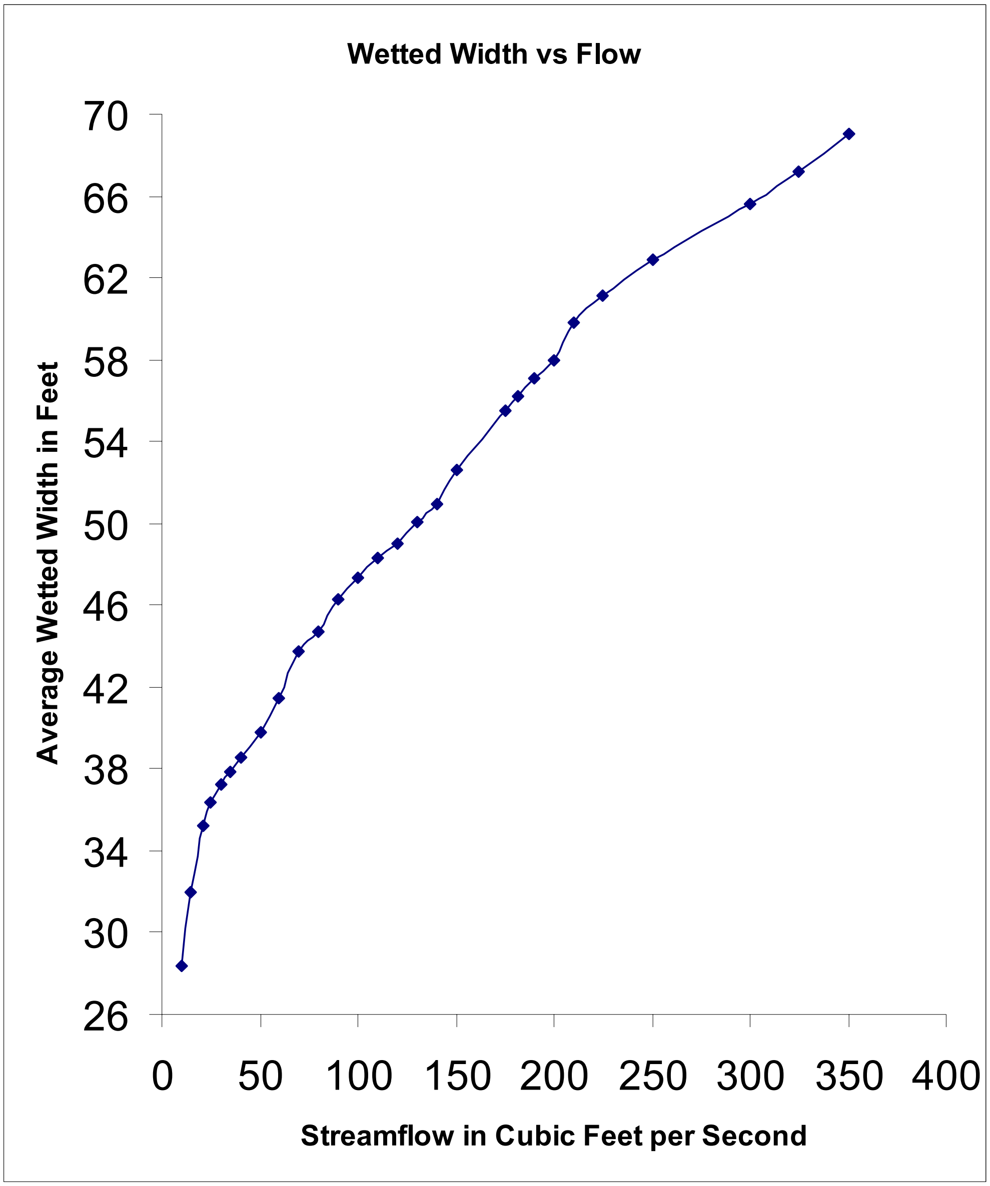
Table 4. Percent of Peak Habitat vs Flow for Walla Walla River below HWY 125.			
Flow (cfs)	**Steelhead Spawning**	**Steelhead Juvenile**	**Chinook Juvenile**
3	0%	15%	11%
5	0%	17%	17%
7	0%	20%	25%
9	1%	22%	31%
11	3%	25%	35%
15	4%	30%	50%
20	9%	38%	59%
25	16%	45%	63%
30	25%	53%	65%
35	34%	59%	66%
40	43%	64%	67%
50	61%	71%	66%
60	77%	77%	63%
70	88%	82%	62%
80	95%	84%	60%
90	**100%**	85%	59%
95	**100%**	85%	59%
100	**100%**	84%	58%
105	99%	84%	58%
110	98%	83%	58%
120	94%	81%	59%
130	88%	81%	60%
140	82%	81%	60%
150	75%	81%	60%
175	67%	84%	63%
200	62%	87%	68%
225	57%	88%	74%
250	54%	92%	80%
300	49%	97%	92%
325	48%	**100%**	**100%**

Figure 7. Average Wetted Width for Mill Creek above Wallula Road.



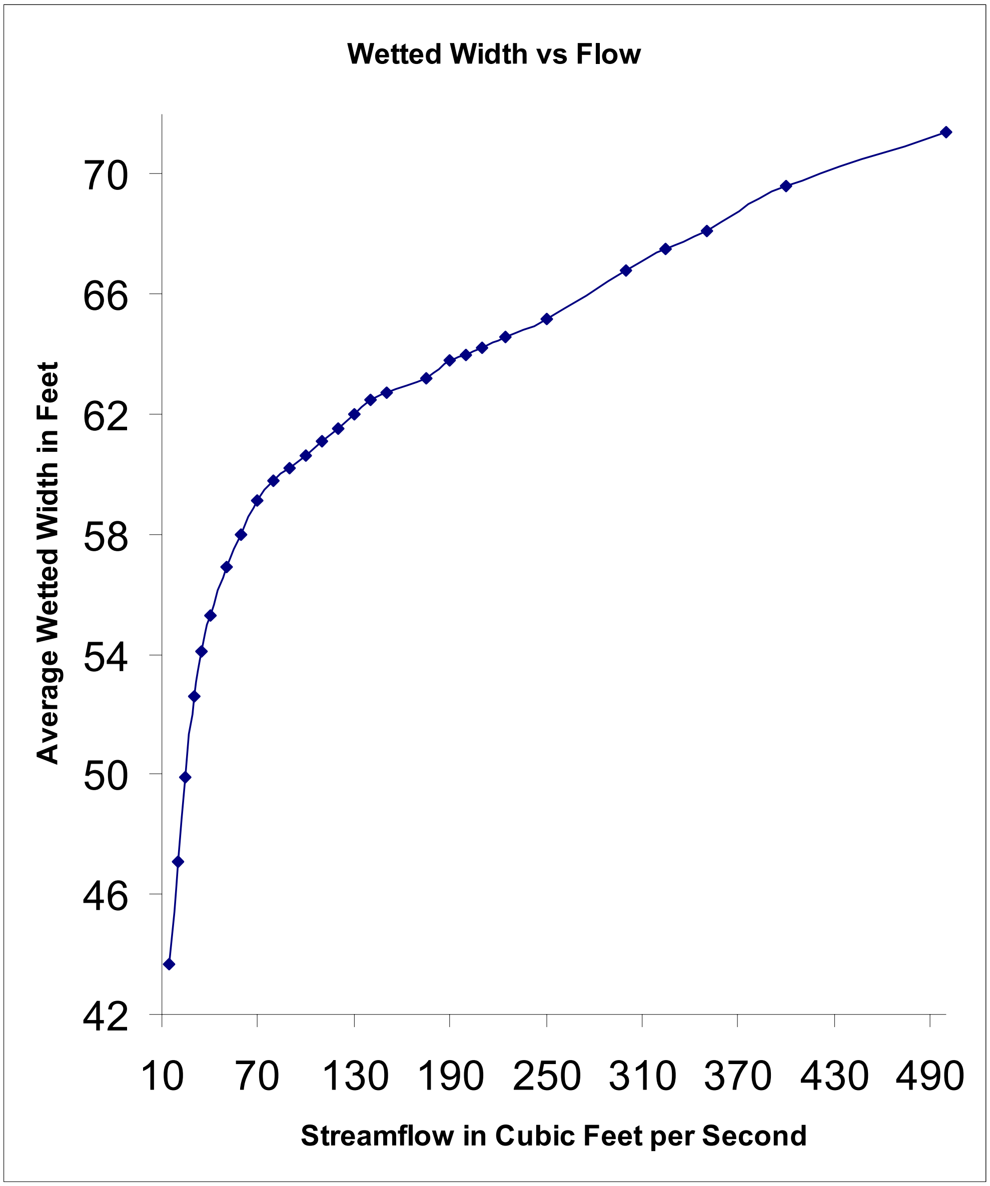
Flow (cfs)	Wetted Width (feet)
3	30.5
4	31.4
5	32.1
6	32.7
8	33.6
10	34.6
12	35.1
15	35.9
18	36.4
20	36.9
22	37.2
25	37.8
30	38.6
35	41.1
40	41.7
45	42.1
50	42.4
56	42.7
60	42.8
65	43
70	43.2
75	43.4
80	43.6
90	44
100	44.2
110	44.4
120	44.6
125	44.7
130	44.9
135	45.1

Figure 8. Average Wetted Width for Walla Walla River below Mill Creek.



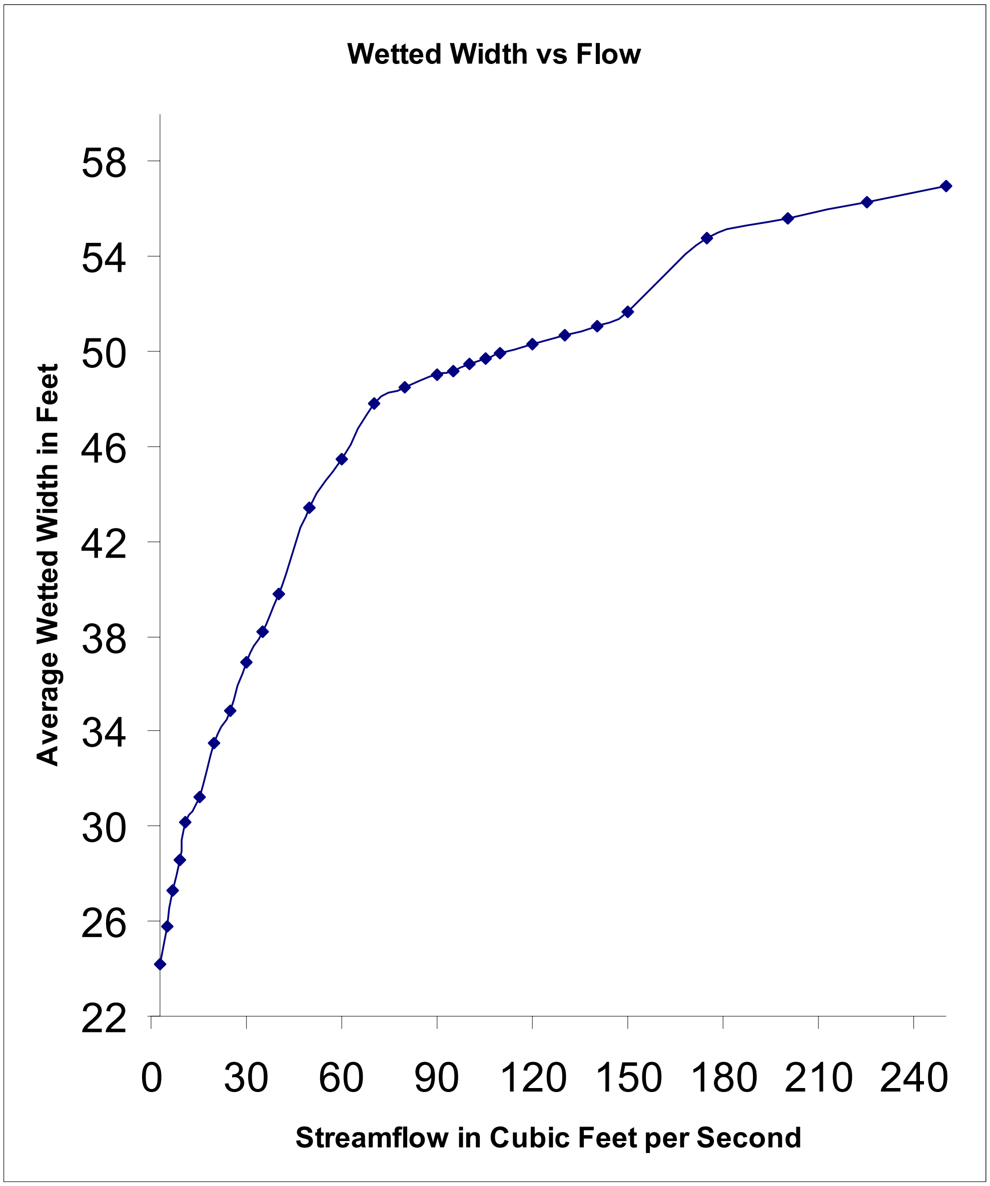
Flow (cfs)	Wetted Width (feet)
10	28.4
15	32
21	35.2
25	36.4
30	37.2
35	37.9
40	38.6
50	39.8
60	41.5
70	43.7
80	44.7
90	46.3
100	47.3
110	48.3
120	49
130	50.1
140	50.9
150	52.6
175	55.5
182	56.2
190	57.1
200	58
210	59.8
225	61.1
250	62.9
300	65.6
325	67.2
350	69

Figure 9. Average Wetted Width for Walla Walla River below Yellowhawk Creek.



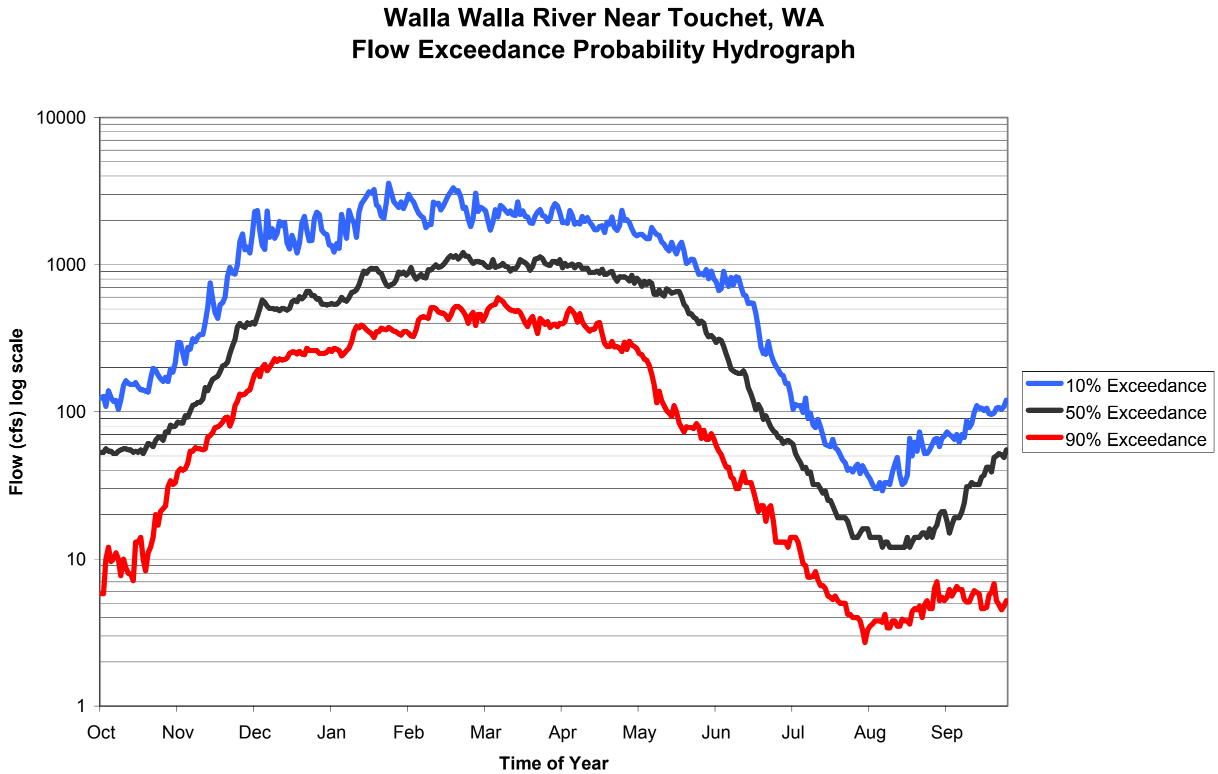
Flow (cfs)	Wetted Width (feet)
15	43.7
20	47.1
25	49.9
30	52.6
35	54.1
40	55.3
50	56.9
60	58
70	59.1
80	59.8
90	60.2
100	60.6
110	61.1
120	61.5
130	62
140	62.5
150	62.7
175	63.2
190	63.8
200	64
210	64.2
225	64.6
250	65.2
300	66.8
325	67.5
350	68.1
400	69.6
500	71.4

Figure 10. Average Wetted Width for Walla Walla River below HWY 125.



Flow (cfs)	Wetted Width (feet)
3	24.2
5	25.8
7	27.3
9	28.6
11	30.2
15	31.2
20	33.5
25	34.9
30	36.9
35	38.2
40	39.8
50	43.4
60	45.5
70	47.8
80	48.5
90	49
95	49.2
100	49.5
105	49.7
110	49.9
120	50.3
130	50.7
140	51.1
150	51.7
175	54.8
200	55.6
225	56.3
250	57
300	58.3
325	58.9

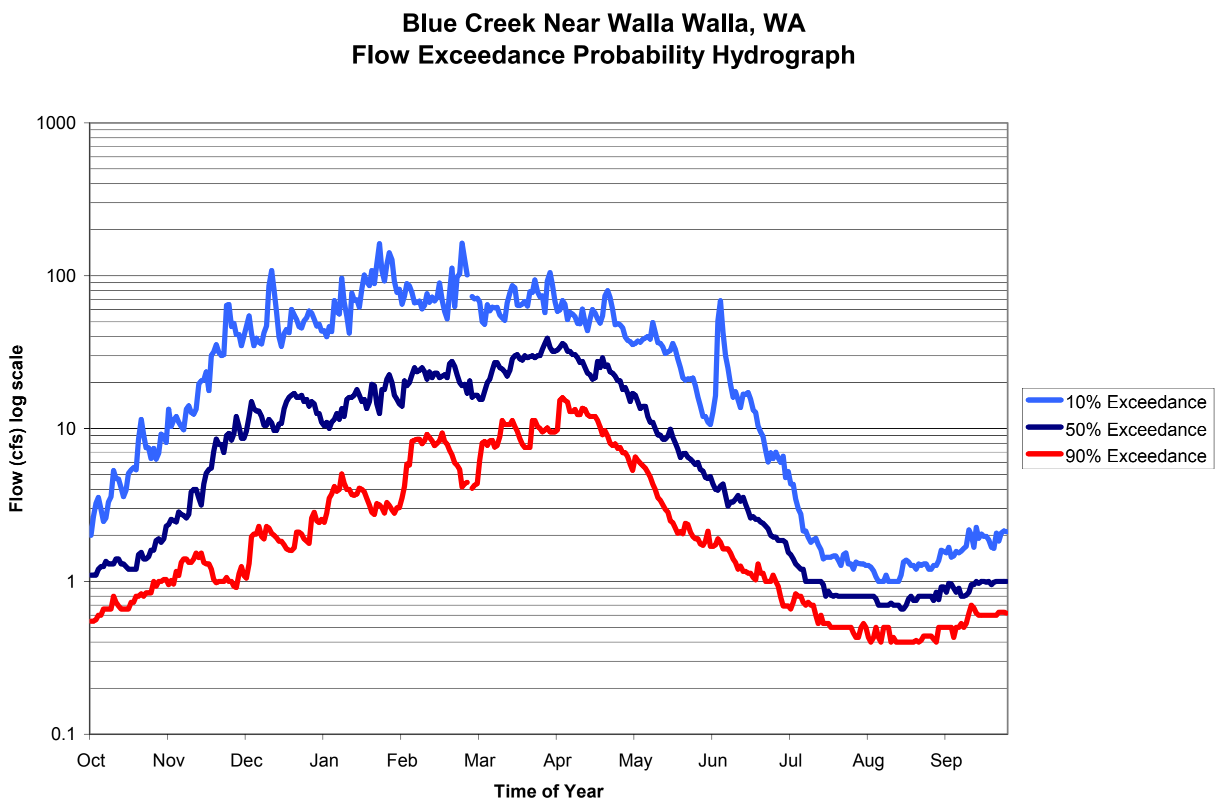
FIGURE 11



USGS Gauge 14018500 WALLA WALLA RIVER NEAR TOUCHET, WASH. (River Mile 18.2, 3.4 miles downstream of Touchet River)

Period of Record: 1951 – 2000

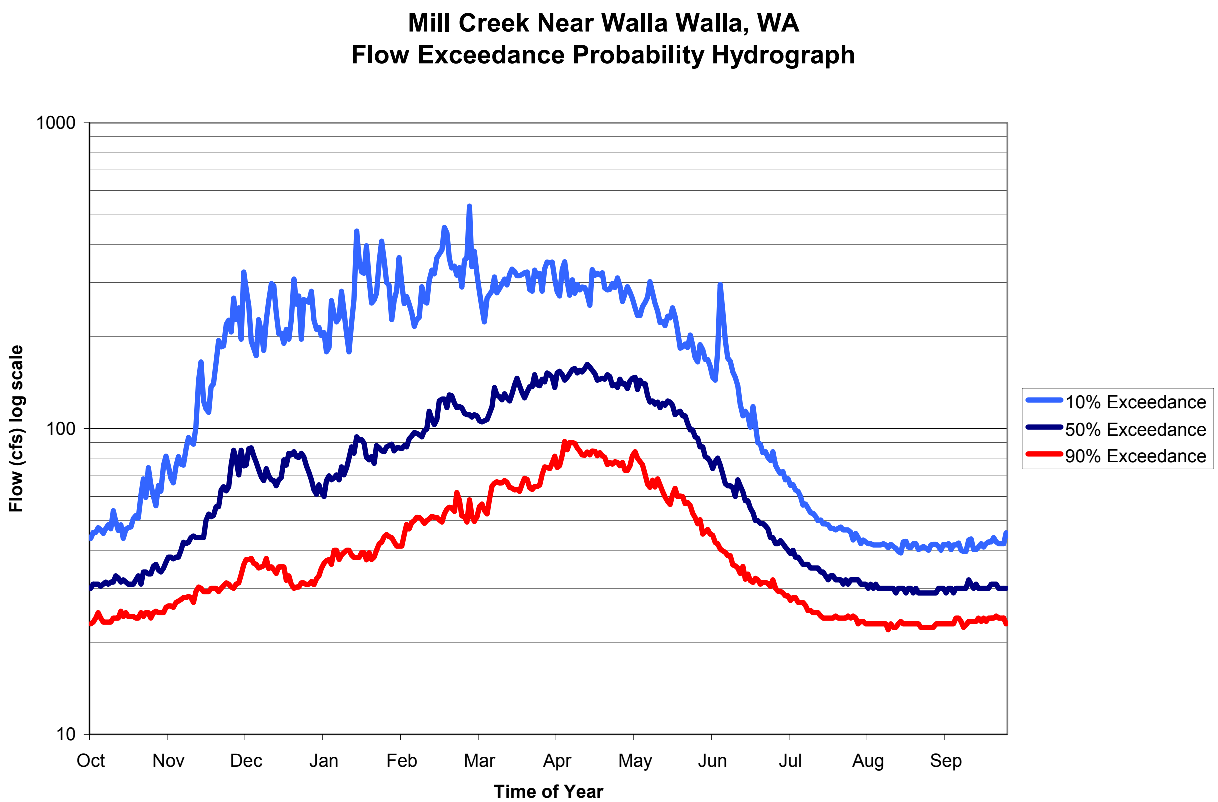
FIGURE 12



USGS Gauge 14013500 BLUE CREEK NEAR WALLA WALLA, WASH. (River Mile 1.0)

Period of Record: 1939 – 1971

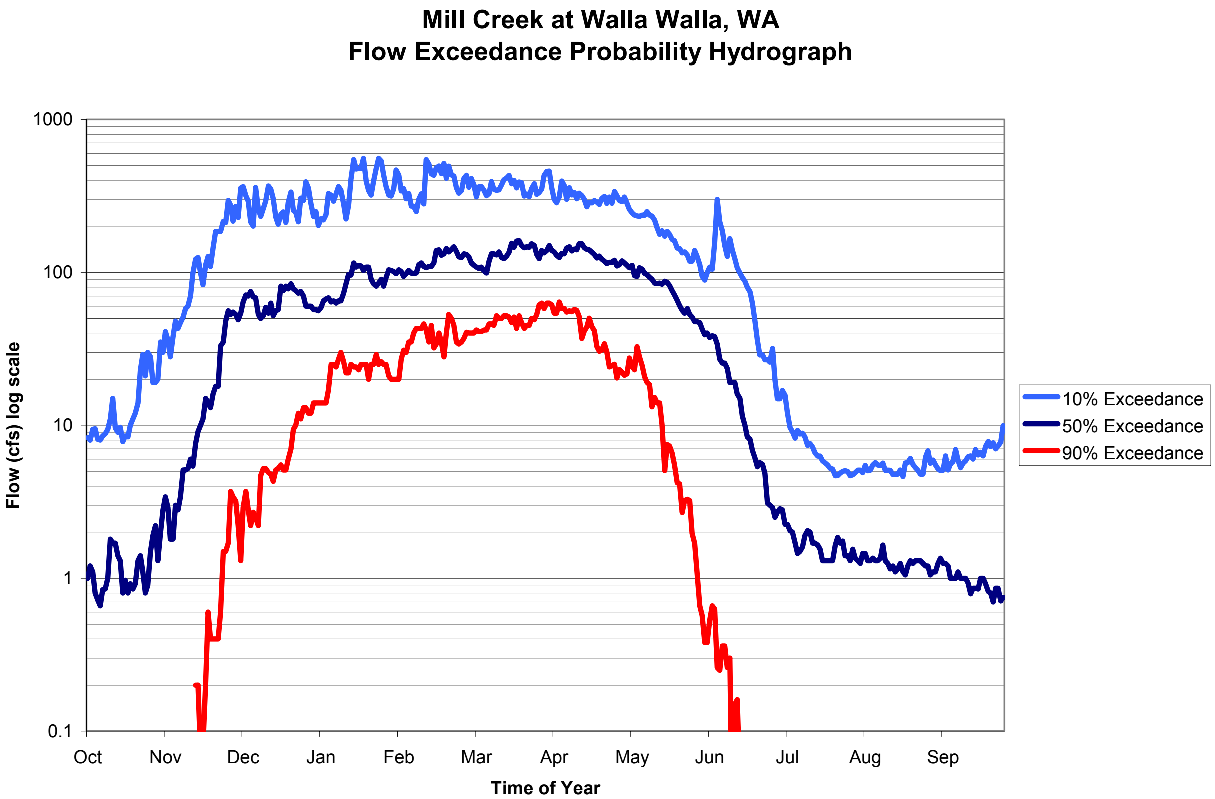
FIGURE 13



USGS Gauge 14013000 MILL CREEK NEAR WALLA WALLA, WASH. (River Mile 21.2, 4.4 miles upstream of Blue Creek, 4 miles downstream of Walla Walla city diversion)

Period of Record: 1913 – 2000

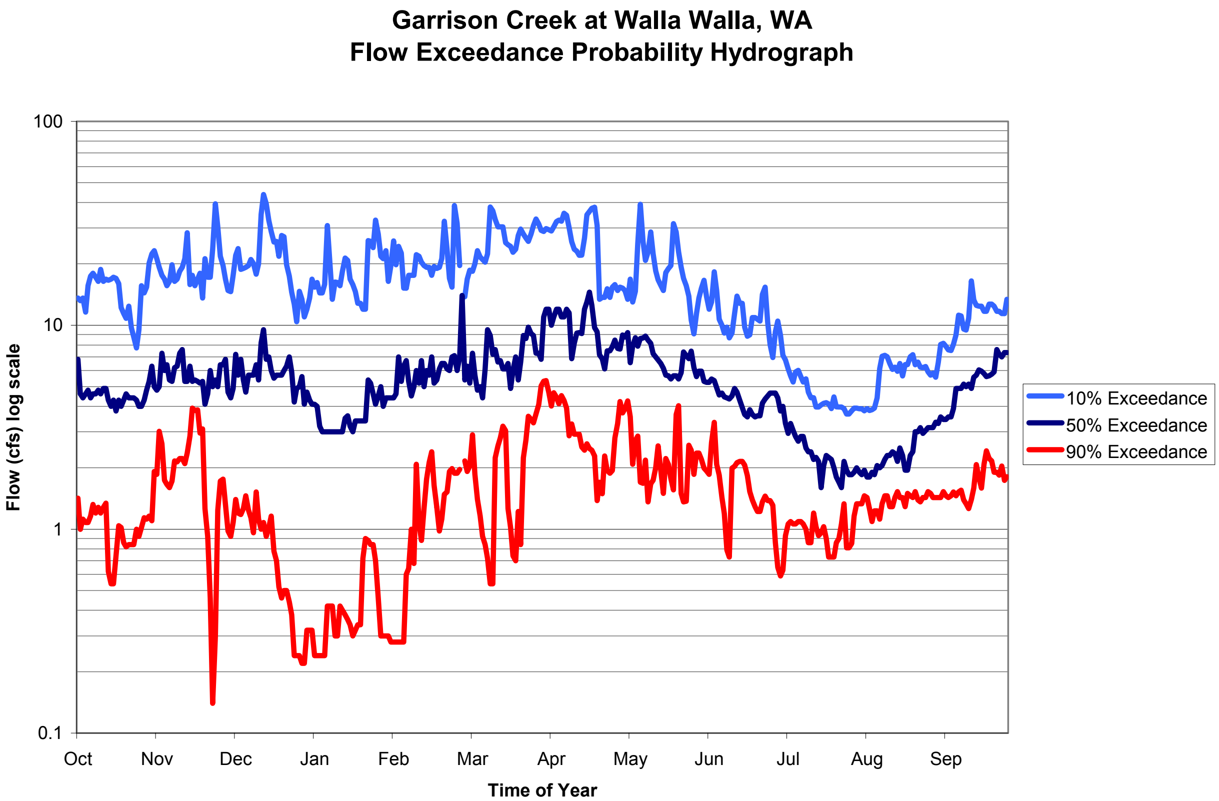
FIGURE 14



USGS Gauge 14015000 MILL CREEK AT WALLA WALLA, WASH. (River Mile 10.5, just downstream of diversion into Yellowhawk Creek)

Period of Record: 1941 – 2000

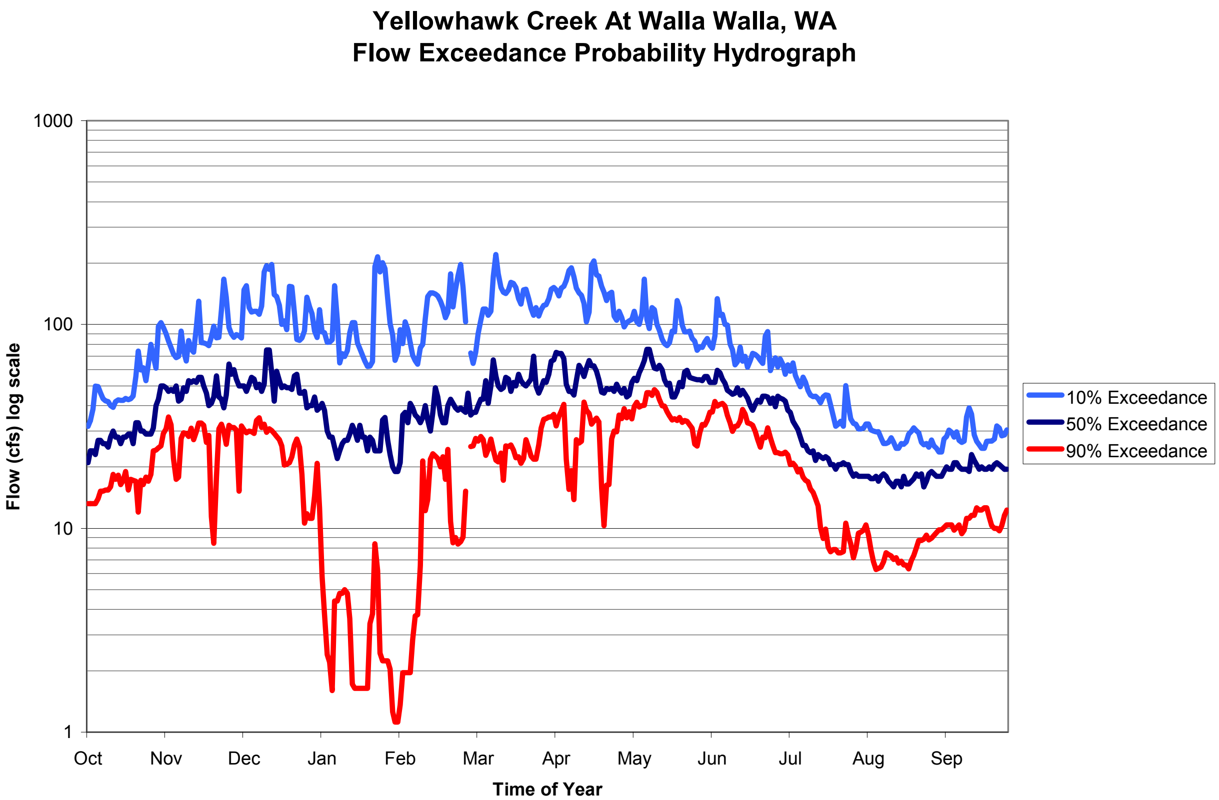
FIGURE 15



USGS Gauge 14014500 GARRISON CR AT WALLA WALLA, WASH. (One mile downstream from diversion from Mill Creek into Garrison Cr)

Period of Record: 1941 – 1952

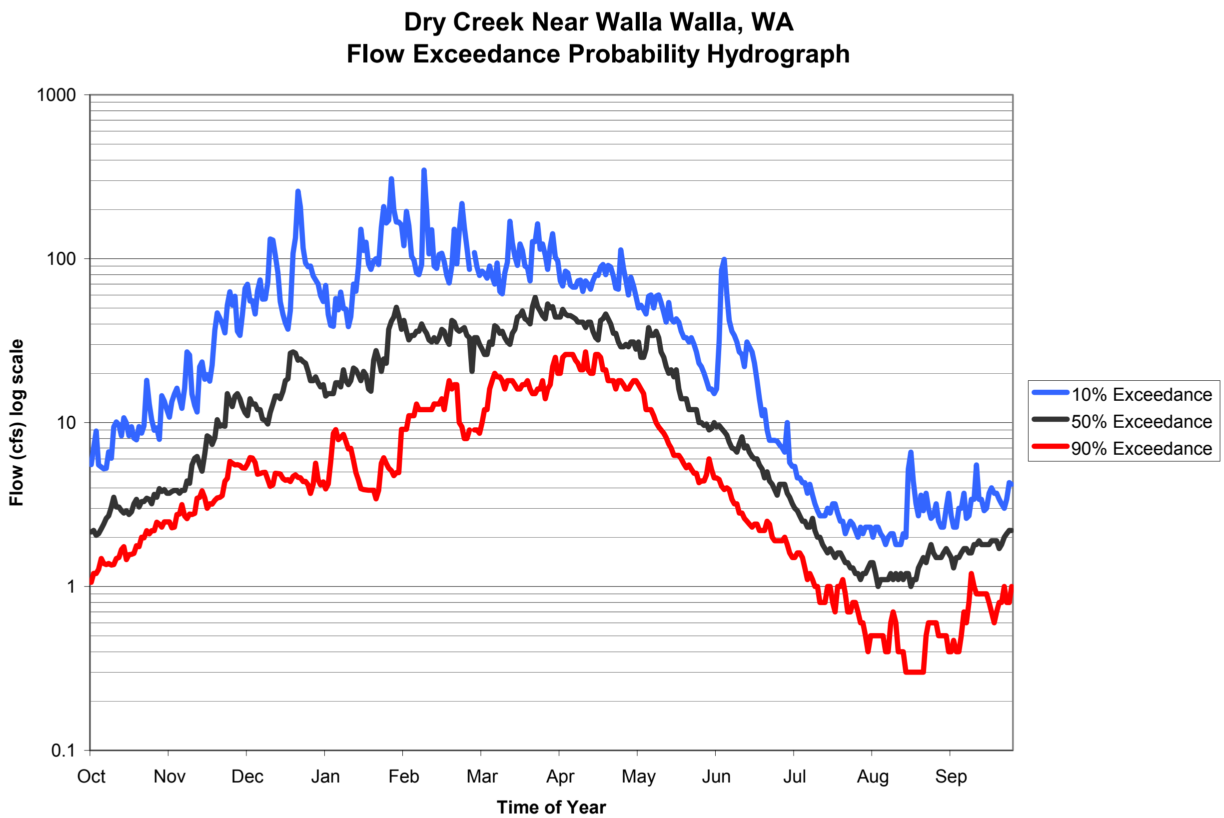
FIGURE 16



USGS Gauge 14014000 YELLOWHAWK CR AT WALLA WALLA, WASH. (One mile downstream from Mill Creek diversion into Yellowhawk, one mile east of Walla Walla)

Period of Record: 1941 – 1952

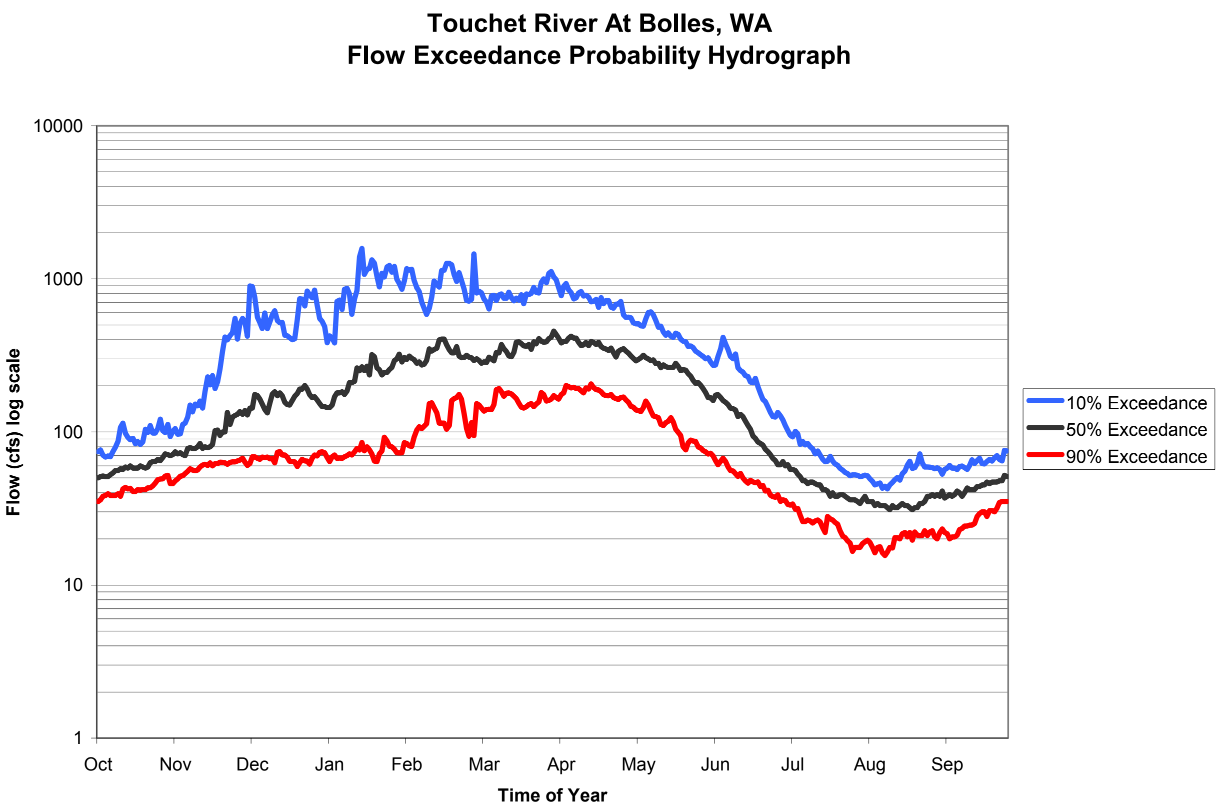
FIGURE 17



USGS Gauge 14016000 DRY CREEK NEAR WALLA WALLA, WASH. (River Mile 22, 1.0 mile downstream of Spring Creek)

Period of Record: 1949 – 1967

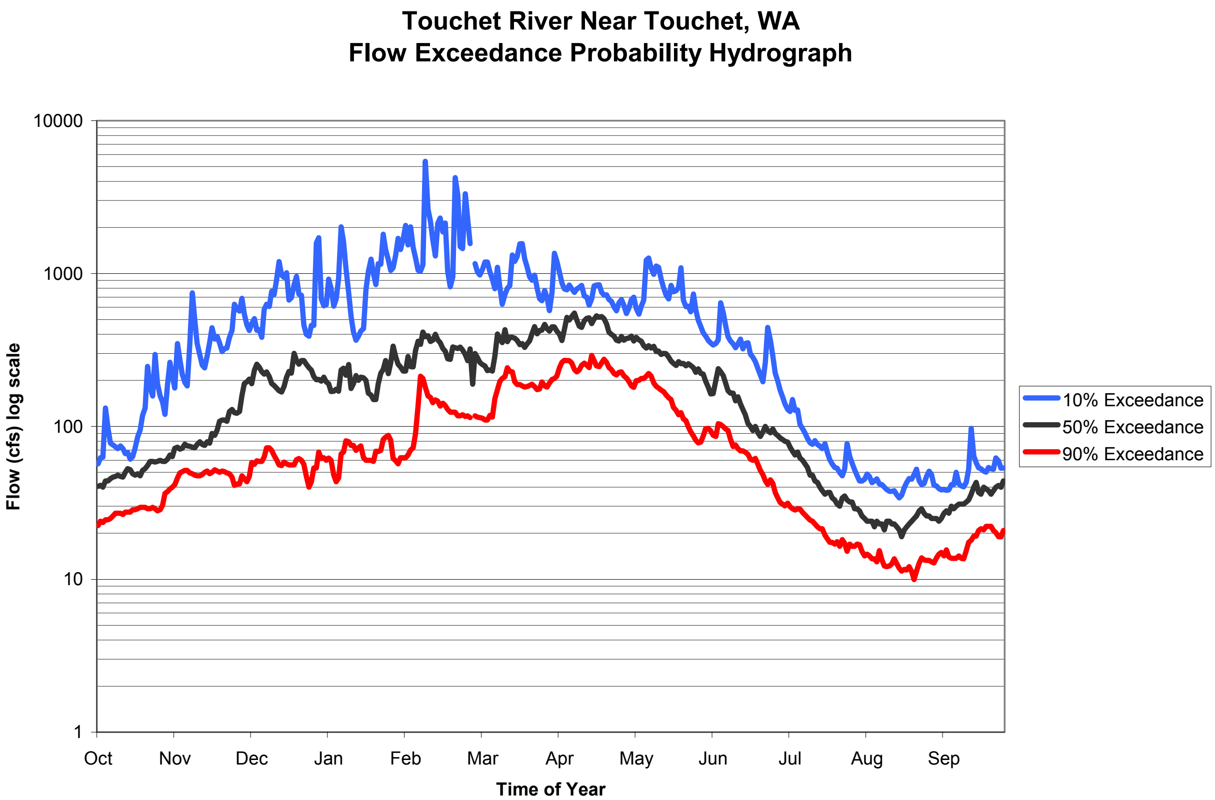
FIGURE 18



USGS Gauge 14017000 TOUCHET RIVER AT BOLLES, WASH. (River Mile 40.1, 2.9 miles downstream of Coppei Creek)

Period of Record: 1924 – 1989

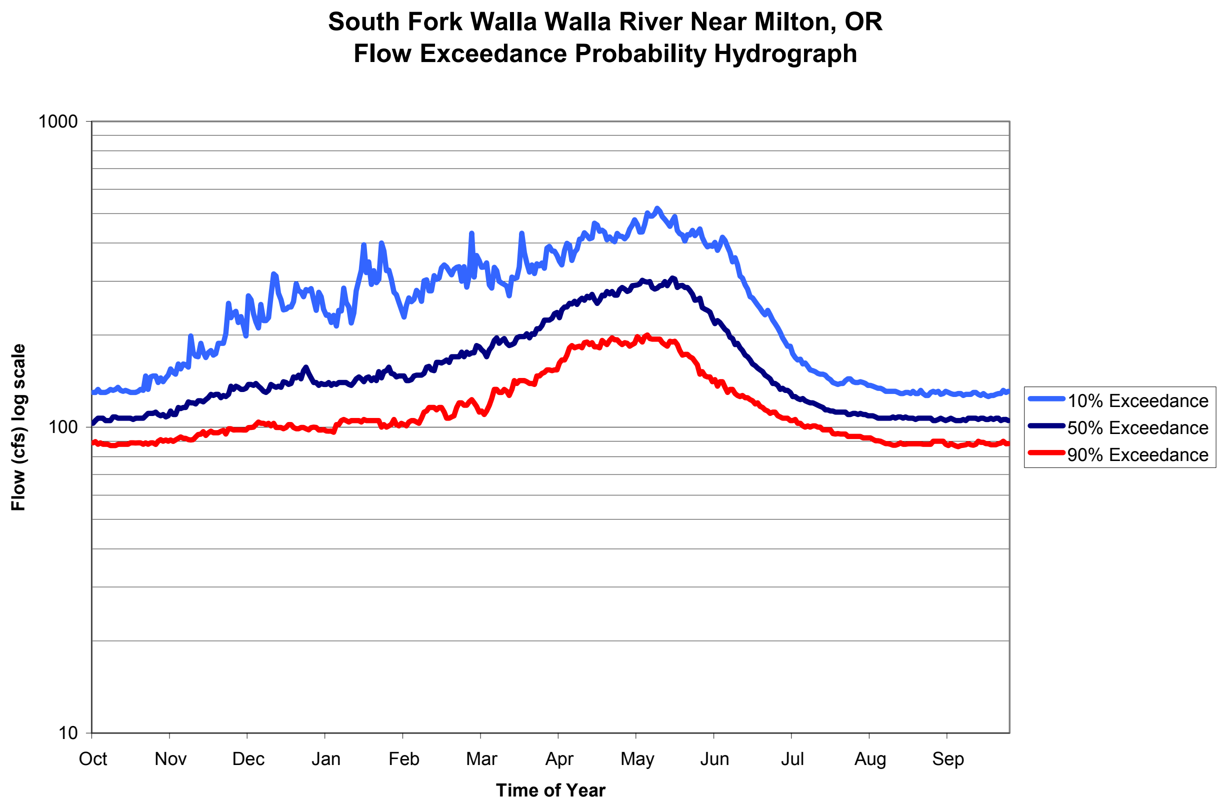
FIGURE 19



USGS Gauge 14017500 TOUCHET R NR TOUCHET, WASH. (River Mile 4.5)

Period of Record: 1941 – 1955

FIGURE 20



USGS Gauge 14010000 SOUTH FORK WALLA WALLA RIVER NEAR MILTON, OREG.

Period of Record: 1903 – 1991

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